ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

DOI: 10.15587/1729-4061.2018.139358

FUEL ECONOMY RAISING OF ALTERNATIVE FUEL CONVERTED DIESEL ENGINES (p. 6-13)

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As a result of the theoretical research, calculations of the theoretical indicated specific fuel consumption for different methods of conversion of diesel engines to gas were carried out. The traditional method of derating in the conversion of diesel engines to gas by installing additional gaskets between the cylinder head and block was considered and the method of derating due to late intake valve closing was proposed.

As a result of in vitro experimental research with different methods of conversion of the Opel X17DTL diesel engine, it was found that using the traditional method of engine derating by installing additional gaskets between the cylinder head and block, the indicated specific consumption increased, on average, by 8–9 %. But with a decrease in the compression ratio of the engine by the proposed method due to late intake valve closing, the experimental value of the indicated specific consumption not only did not increase, but decreased, on average, by 7–8 %. The reduction of the compression ratio of the engine due to late intake valve closing by the proposed method was carried out by changing the shape of the camshaft cams. To this end, the cams of the intake valves were fused and then ground to the desired profile, with which late intake valve closing occurred within the predetermined limits.

The results obtained allow optimizing the processes of conversion of diesel engines to gas and reducing the fuel consumption of converted engines, on average, by 15–17 % compared to gas engines converted in a traditional way.

Keywords: alternative fuels, diesel engine, engine conversion to gas, specific fuel consumption.

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DOI: 10.15587/1729-4061.2018.139473

DEVELOPMENT OF ENERGY-SAVING TECHNOLOGY FOR MAINTAINING THE FUNCTIONING OF HEAT PUMP POWER SUPPLY (p. 13-24)

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An integrated system of maintaining functioning of heat pump power supply based on prediction of a change of local water temperature was developed. A change in refrigerant vapor flow rate, the number of rotations of the electric motor of the compressor occurs at measuring of the refrigerant temperature at the outlet of the condenser, evaporation pressure, condensation pressure and voltage frequency. Comprehensive mathematic modeling of the heat pump system, based on the integrated system of maintaining soil heat discharge at the level of 8–10 °C was performed. Refrigerant flow rate, compressor motor power, voltage, voltage frequency, the number of rotations of electric motor of the compressor, coefficients of efficiency of a heat pump system for the established levels of functioning were determined. Parameters of convective heat exchange in the condenser, time constants and coefficients of the mathematical models of dynamics of a change in local water temperature, refrigerant flow rate, the number of rotations of the electric motor of the compressor were established. The functional estimation of a change in local water temperature in the range of 35–55 °C within the heating season, refrigerant vapor flow rate, the number of rotations of the electric motor of the compressor was obtained. Determining of the resulting functional information allows makes it possible to obtain the following advancing decisions: to maintain a change in evaporation pressure to change the refrigerant vapor flow rate for digital control; to maintain a change in evaporation pressure to change the refrigerant vapor flow rate and to change voltage frequency on a change of the number of rotations of the electric motor of the compressor for frequency control.

That is why prediction of a change in local water temperature based on measurement of the refrigerant temperature at the outlet of the condenser was proposed. This estimation in the ratio with the measured evaporation pressure is included in analytical determining of refrigerant flow rate and the number of rotations of the electric motor of the compressor. Obtaining such estimation and measurement of frequency voltage makes it possible to make an advancing influence on coordination of functioning of the internal and external circuits of a heat pump system both at digital and frequency control.

Keywords: heat pump system, frequency control, digital control, evaporation pressure, condensation pressure.

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DOI: 10.15587/1729-4061.2018.139392

IMPROVEMENT OF CAVITATION EROSION CHARACTERISTICS OF THE CENTRIFUGAL INDUCER STAGE WITH THE INDUCER BUSH (p. 24-31)

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The impact of the inducer bush, which is a stator bush with longitudinal straight grooves installed over the inducer in the model centrifugal stage on its performance, was studied. A physical experiment was performed with the use of the experimental design techniques to solve the problem of geometrical parameter optimization of the stator bush with longitudinal straight grooves in the multi-factorial problem regarding the improvement of cavitation erosion characteristics of the centrifugal inducer stage using the inducer bush. The frequency spectrum of excited oscillations of the studied centrifugal inducer stage caused by cavitation was determined in order to use the cavitation erosion resistance parameter as an optimization parameter. The optimal dimensions of the inducer bush of the studied centrifugal inducer stage were experimentally determined: Z=32, b=14, l_1=20, and l_2=20. This data allowed us to improve the cavitation erosion resistance of the centrifugal inducer stage without changing its overall dimensions and deteriorating head and power characteristics. An additional physical experiment was performed using an alternative method for determining the cavitation and erosion characteristics in order to confirm the results obtained in the study due to inducer bushes installed in the centrifugal inducer stage. The use of inducer bushes as a part of the centrifugal inducer stage was mainly intended to improve the centrifugal stage cavitation performance. This study proposes to use this part to overcome the negative effects of cavitation erosion. The possibility of such use was confirmed and research and methodological design recommendations for inducer bushes as part of the centrifugal inducer stage were developed. The installation of the improved first centrifugal stages with inducer bushes in the existing centrifugal pumps will increase the operating time to failure, which is relevant for all industries where centrifugal pumps are used.

Keywords: centrifugal pump, centrifugal inducer stage, inducer bushes, cavitation erosion resistance.

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DOI: 10.15587/1729-4061.2018.139399

CONSTRUCTING A MATHEMATICAL MODEL OF THE GAS-DYNAMIC SEPARATION FOR DESIGNING ENERGY-SAVING VORTEX SEPARATORS (p. 32-39)

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We developed a mathematical model of the separation process of heterogeneous polydisperse mixtures in the proposed energy saving vortex separators, which is represented by a system of differential equations linking parameters of the process control to the geometric dimensions of device. We showed the possibility to solve a mathematical model based on the grid method for the determination of initial parameters and control parameters of the separation process, as well as for determination of coordinates of components with different shapes, densities, aerodynamic and gas dynamic properties. This will significantly reduce time for calculations of gas-dynamic vortex separators of any mixtures. We proved the reliability of the calculation based on the grid method by comparing it with the results of the experiment. This makes it possible to calculate and design vortex separators without expensive calibrating sieves and energy-intensive vibration equipment. We established the region of a change in the generally accepted coefficients of efficiency and precision of the separation of a flour mixture, which

determine the presence of harmful components in a resulting product and the content of high quality components in waste, which should not exceed 2 %.

We detected boundary values of the coefficients of efficiency η_e=88 % and precision η_s=0.9 of mixtures of flour of the highest grade, the first grade, and the second grade, which could be used as the initial data in the design of vortex separators. We proved the possibility to control the separation process by changes in gas-dynamic parameters of a heterogeneous mixture at the inlet to a separator. This will make it possible to change the velocity of redistribution of components of a mixture and to obtain necessary indicators of a resulting product with a predetermined degree of purity. The research results proved the possibility for implementing vortex separators into industrial production. This will significantly reduce the cost of preparation of raw materials in grain processing, coal, and other fields, as well as in the production of dolomite, construction materials, etc. Using the vortex gas-dynamic separators in technological processes would improve production environment and reduce the cost of maintenance and repair, since they operate in a closed cycle and do not contain expensive calibrating sieves and electric drives.

Keywords: vortex separator, heterogeneous mixture, gas-dynamic parameters, coefficient of efficiency, coefficient of precision, productivity.

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DOI: 10.15587/1729-4061.2018.139445

NUMERICAL STUDY OF FLOWS IN AXIAL COMPRESSORS OF AIRCRAFT GAS-TURBINE ENGINES (p. 40-49)

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Design and adjustment of compressors at modern gas-turbine engines are based on the wide use of numerical analysis methods of a various level of complexity. Such approaches make it possible to analyze the alignment of joint operation of stages and to perform the required correction of geometrical parameters. The methods for calculating the 1D and 2D flow in compressors are distinguished by high flexibility, which allows the utilization of considerable experience in designing and experimental research. These methods are consequently in demand at all stages of the engine life cycle: when creating, adjusting, at operation.

We present methods for the calculation of parameters and structure of current, as well as the summary characteristics of axial stages and multistage compressors. To solve a system of motion equations, we employed a matrix method, which makes it possible to apply small computation grids in a flow-through part of the compressor. The method is designed to numerically simulate the sub-, trans-, and supersonic flows in the flow-through part of axial compressor stages and multistage axial compressors at aircraft engines. The methods are implemented in the form of software complexes.

The article reports certain results related to the verification of these complexes. We use data from experimental studies into

various multi-stage compressors and high-head fan stages. We show a satisfactory agreement between calculated and experimental data over a wide range of modes of consumption and rotation frequency.

The developed software package was used to improve the geometrical parameters for an axial multi-stage compressor, aimed at increasing the air flow rate through the compressor and enhancing the reserve of its gas-dynamic stability.

Employing small computational grids made it possible to undertake a series of studies, previously available only for the calculation methods of spatial flow. We considered different variants for the execution of the bushing surface at a high-head fan stage. When analyzing the structure of flow in a stage, we show the change in the axial component of velocity in a blade-to-blade channel of the impeller along its axis.

Development and application of the new methods of calculation will improve the quality of design of axial compressors and enhance competitiveness of the Ukrainian aircraft gas turbine engines.

Keywords: calculation of transonic flow, matrix method, multistage axial compressor, fan stage.

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DOI: 10.15587/1729-4061.2018.139314

THEORETICAL RATIONALE AND IDENTIFICATION OF HEAT AND MASS TRANSFER PROCESSES IN VIBRATION DRYERS WITH IR-ENERGY SUPPLY (p. 50-58)

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The paper contains theoretical substantiation of the processes of radiation-convective heat and mass transfer between all the defining objects inside the vibration dryer with IR energy supply. The presented equations, developed on the basis of the heat and material balance, describe the basic dynamic characteristics of the drying mode for oil-bearing grain material in a continuously operating IR dryer.

Since there is no exact analytic solution of the presented mathematical model shaped as a system of differential equations with partial derivatives, the authors propose an approximate solution. The latter allows identifying the dependences between the distribution of temperature and moisture content of grain and oil-containing materials along the length of the dryer for any moment of time.

The numerical solution of the reduced mathematical model is possible only with the presence of certain interconnected kinetic coefficients. The kinetic coefficients can not be found experimentally by direct measurements; therefore, the article proposes a method to overcome these difficulties. The presented approximate analytical solution of the synthesized mathematical model, with the use of the method of inverse problems, has allowed determining sets of coefficients by the results of the experimental identification of dehydration. In the future, experimentally identified parametric complexes of the model can be used in the analysis of the drying process for approximate solutions or for further exact numerical solution.

Experimental studies of dehydration of grain material have proved that when the power of an IR source is increased from 400 to 500 W, the time for drying from the initial moisture content of 11 % to 8.75 % decreases from 9 to 7 minutes. It is determined that the Rebinder effect characterizing the dampness and thermal properties of the material decreases with a decrease in the moisture content from 0.04 at 11 % to 0.01 at 9 %. This is interesting from the practical point of view as the obtained results and the developed mathematical model can be used for increasing the energy efficiency of the processes of thermal drying in typical facilities that prepare oil-bearing grain materials for their processing.

Keywords: heat and mass transfer, infrared energy supply, vibration dryer, oil-bearing grain, parametric identification.

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DOI: 10.15587/1729-4061.2018.139418

AN EXPERIMENTAL STUDY OF THE EFFECT OF NANOPARTICLE ADDITIVES TO THE REFRIGERANT R141b ON THE POOL BOILING PROCESS (p. 59-66)

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The results of the experimental study of the internal characteristics of the pool boiling process of the refrigerant R141b, solution R141b/surfactant Span-80 and nanofluid R141b/Span-80/ TiO_2 nanoparticles on the surfaces of stainless steel and teflon have been presented.

The measurement of the vapor bubble departure diameter, the vapor bubble departure frequency and the nucleation site density has been performed at atmospheric pressure and in the range of heat fluxes from 3.0 to 7.5 $kW \cdot m^{-2}$.

The study showed that the vapor bubble departure diameter in nanofluid boiling on the stainless steel surface is 0.7 mm and on the teflon surface – 0.45 mm. Besides, the additives of nanoparticles to the solution of R141b/Span-80 lead to a decrease in the vapor bubble departure diameter in boiling on the teflone surfaces. The opposite effect was detected in boiling on the stainless steel surface.

It is shown that the additives of TiO_2 nanoparticles to the solution R141b/Span-80 lead to a decrease in the number of nucleation sites by 2–8 times. This effect depends on the heat flux and type of heaters surface.

It was found that the rise of the heat flux leads to an increase in the difference between the magnitudes of nucleation site density for the teflon and stainless steel surfaces in boiling of R141b and R141b/Span-80.

The number of nucleation sites on the teflon surface is 2 times lower compared with boiling on the stainless steel surface at a heat flux of 7.5 $kW \cdot m^{-2}$. The type of surfaces does not affect the number of nucleation sites and vapor bubble departure frequency in nanofluid boiling in the entire investigated range of heat fluxes.

Based on the results of the study, it was found that the vapor bubble departure frequency in boiling of R141b and solution R141b/Span-80 on the teflon surface is 1.5–2 times lower compared with boiling on the stainless steel surface.

The obtained experimental data can be used in predicting the heat transfer coefficient in boiling of the solution of R141b/Span-80 and nanofluid R141b/Span-80/TiO_2.

Keywords: nanofluid, vapor bubble departure diameter, vapor bubble departure frequency, nucleation site density.

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